Modulation of auditory cortical activation by attention demonstrated with functional MRI

***P.W.R. Woodruff, R.R. Benson, T. Talavage, K.K. Kwong, P.A. Bandettini, J. Goodman, J.W. Belliveau, B.R. Rosen.**

Massachusetts General Hospital NMR -Center, Boston, USA
**Institute of Psychiatry, London, UK.*

Introduction

Attention is a process by which cognitive events are focused on a particular subset of all possible stimuli to increase the efficiency of performance of a task. Despite the detailed models of attention proposed by Mesulam, and Posner, the stage at which the neural network underlying attention interacts with perceptual processing is not known. Woldorff et al. [1] used neuromagnetic imaging (MEG) to investigate this question and localized "attention-sensitive brain responses" in the superior temporal plane near Heschl's gyrus. Functional MRI (fMRI) has successfully been used to image primary auditory cortex [2]. Our objective in this study was to exploit the high spatial and temporal resolution of fMRI to investigate where in the auditory processing pathway attention exerts a modulatory effect.

Subjects and Methods

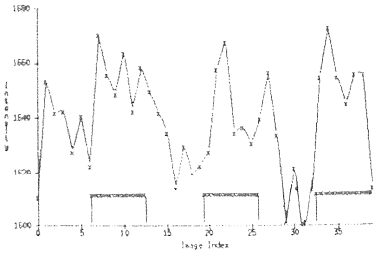
Four healthy right-handed male subjects 25-38 years old were imaged whilst alternately attending to either visual or auditory stimuli. Subjects were simultaneously presented with pseudorandom numbers (1-9) visually and aurally and instructed to press a key when they either *heard* or *saw* the number "8". They were cued with "listen" or "look" at transitions. Additionally, in two subjects, stimuli were presented at different rates (0.2, 0.4, 0.8,1.6 Hz.) in order to maximise the probability of detecting modulated activity. A 1.5 Tesla GE Signa scanner with EPI and a surface coil placed over the left temporal lobe were used with an ASE sequence (TR=1.2-1.75; 200 images per slice; voxel size 3x3x5mm). The upper border of the temporal lobe parallel to the Sylvian fissure defined the most superior of 5 contiguous slices. Statistical maps were generated using the Kolmogorov-Smirnov statistic between conditions. Anatomical localisation was achieved using high resolution MRI images and Talairach normalization.

Results

One subject was excluded from further analysis due to excessive head motion. The spatial extent of activation of primary auditory cortex increased progressively (13, 27, 138, 155 pixels, respectively) with increasingly higher rates of stimulus presentation. The largest interval increase was observed between 0.4 and 0.8 Hz. For all three subjects "auditory attend" minus "visual attend" demonstrated regions of significant activation ($p < 0.05$) in primary auditory cortex (Brodman areas 41-42). For two subjects, activation was greatest in higher order auditory areas, i.e, posterior STG and MTG (Brodman area 22 and 21, respectively) (see figure). The diffence in signal magnitude between auditory and visual attention conditions ranged from 1-3%.

Conclusions

The results: 1) confirm that activation of primary auditory cortex increases with rate of stimulus presentation; 2) indicate that auditory cortical activity is modulated by attention at the lowest level (primary) as well as at higher levels of auditory cortical processing.



Signal during auditory and visual attention within Brodmann's Area 21. Auditory attention condition denoted by blocks at base of graph.

References

1 Woldorff MG et al. Proc. Natl. Acad. Sci. 1993, 90: 8722-6.

2 Binder JR et al. Cognitive Brain Research. 1994, 2:31-8.